How to Describe Multiple Versions of the Same?

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Abstract: The IEEE LTSC Learning Object Metadata (LOM) standard has become the primary standard for describing learning objects and is now used on a massive scale. This paper proposes and discusses three solutions for describing different versions of the same learning object. Such versions could be resources in different formats, languages, accessibility, etc. Currently, there is no best practice in current standards like LOM etc. how to capture this information. We propose a recursive LOM approach where a LOM instance can be an aggregate of multiple LOM instances.

Introduction

In recent years, the IEEE LTSC Learning Object Metadata (LOM) standard (IEEE LTSC, 2002) standard has become the primary standard for the description of learning objects (Wiley, 2007) and it is now used on a massive scale. It has enabled interoperability between numerous systems. For instance, the GLOBE consortium uses LOM to enable search on educational resources across the world. ASPECT is a 30-month Best Practice Network supported by the European Commission's eContent*plus* Programme (ASPECT, 2008). Technology providers and standards' experts in ASPECT work together with content providers to develop best practice approaches to implementing standards for both educational content discovery and use. In ASPECT, content providers describe their content with LOM. All metadata instances are pulled from the providers by using the ARIADNE harvester (Ternier, S., et. al, 2009). This tool makes use of the OAI-PMH specification (Sompel, H., et. al, 2004) for harvesting metadata. Afterwards, the metadata is published with the Simple Publishing Interface (SPI) (Ternier, S et. al, 2008) into a general metadata store where they can be found by end users and possibly used.

While experience has been building up in ASPECT, a number of interrelated shortcomings of LOM have been identified:

1. The need for describing different versions of a learning object (LO) became apparent because Learning Objects (LOs) are nowadays often available in different formats. For example, the OpenLearn initiative of the Open University (UK) produces its content in eight different formats such as SCORM, Common Cartridge, etc.
2. Besides that, there may be different versions available for an individual LO such as different language versions, but e.g. also several versions for people with disabilities. Examples may be: an audio version for the blind, a version avoiding red for the colour blind, etc.
3. Furthermore, each different version or format of a LO could have some different metadata facets such as audience or rights.

We start this paper with a brief overview of IEEE LOM. Following this overview, we introduce an example that will be used while explaining all solutions. This paper then describes three different solutions for the issue at

hand. These solutions are evaluated and compared in the discussion section. We conclude this paper with future work in the last paragraph.

Learning Object Metadata (LOM)

For completeness, we briefly present an overview of IEEE LOM (IEEE LTSC, 2002) in this section. The goal of LOM is to enable sharing of descriptions of learning resources. Relevant attributes of learning objects to be described include: title, author, owner, format, interaction style, etc. The elements of LOM are organized into nine categories:

1. General: description of the learning object as a whole.
2. Life Cycle: history and current state of the learning object.
3. Meta-Metadata: information about the metadata instance.
4. Technical: technical requirements and characteristics.
5. Educational: educational and pedagogical characteristics.
6. Rights: intellectual property rights and conditions of use.
7. Relation: the relationship with other learning objects.
8. Annotation: comments on the educational use of the learning object.
9. Classification: relation to a particular classification system.

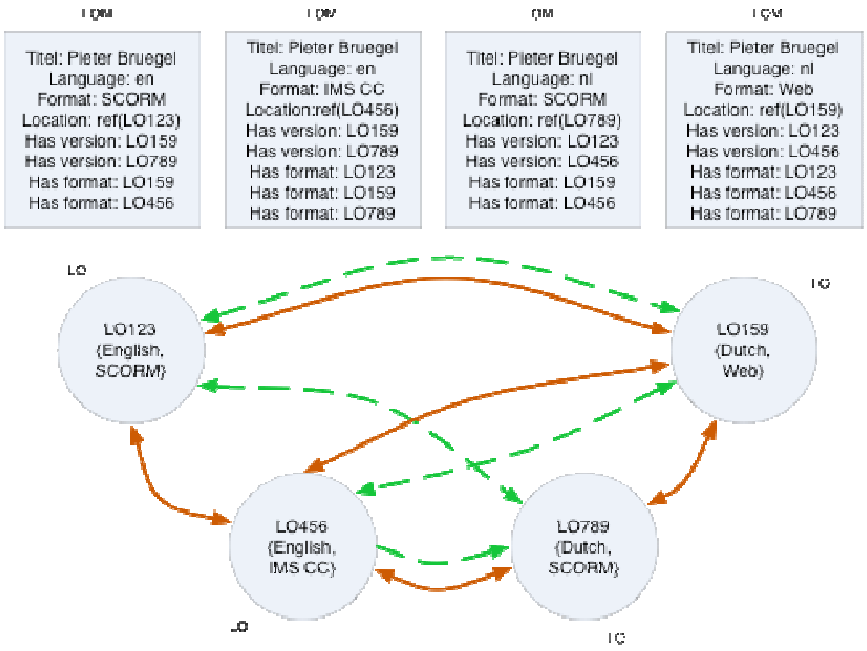

Fig. 1: This example LO on a painting of Bruegel the Elder shows the current use of relations in LOM

Versions and formats of a learning object

To describe the different solutions of capturing different versions and formats, we use an example. Consider the following related learning objects about The Flemish painter Bruegel the Elder. The four related learning objects have different languages and formats, namely in:

- English in IMS Common Cartridge format
- English in SCORM format
- Dutch in SCORM format
- Dutch web based hypermedia

These relationships are represented in Fig. 1 where the dashed lines represent the relation “hasFormat”. The other style represents the “hasVersion” relationship. The problem with basic LOM is that these different versions of languages and formats of the same LO are difficult to handle. While section 7 of the LOM (relation) may point to different versions and formats, in fact they point to different learning objects — *not metadata* —

without the possibility to describe these versions and formats. The disadvantages are that with many formats and versions this leads to a combinatorial explosion of relationships in section 7 of the LOM as can be seen in Fig. 1. In the following sections, we discuss three different techniques of dealing with this situation:

- Create a wrapper around LOM instances.
- Qualify the LOM location
- Create recursive LOM instances.

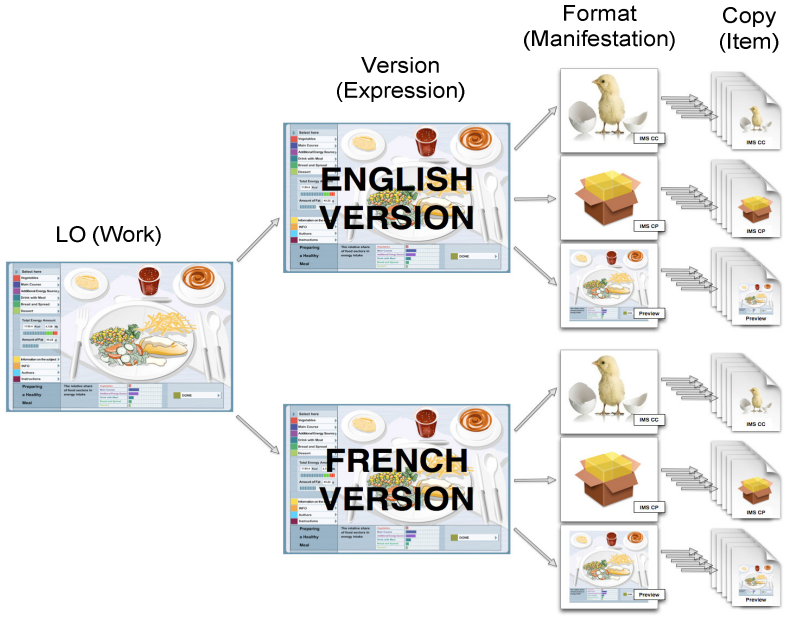

Fig. 2: Example ILOX components: different versions and formats of the same LO

Create a wrapper container around LOM

FRBR is the conceptual model for the bibliographic universe known as "Functional Requirements for Bibliographic Records" (IFLA, 1998). The IMS LODE working group applies this model to the learning object paradigm (IMS LODE, 2009). This is known as the "Information for Learning Object exchange" specification (ILOX). Fig. 2 shows an example of the learning object of Pieter Brueghel in ILOX. In this example, an *item* might be a copy of a learning object that has been downloaded by a user. A *manifestation* might be the SCORM version of the learning object while another manifestation such as IMS common cartridge and a preview also exists. Different language *expressions* of the learning object are available which are realized through the *work*.

```
<expression>
  <identifier>
    <catalog>ASPECT</catalog>
    <entry>1</entry>
  </identifier><name />
  <description>
    <metadata>
      <schema>http://ltsc.ieee.org/xsd/LOM</schema>
      <lom xmlns="http://ltsc.ieee.org/xsd/LOM"
        xsi:schemaLocation="http://ltsc.ieee.org/xsd/LOM http://ltsc.ieee.org/xsd/lomv1.0/lomLoose.xsd">
        <general>
          <identifier>
            <catalog>ASPECT</catalog>
            <entry>1</entry>
          </identifier>
          <title>
            <string language="en-gb">Pieter Bruegel</string>
          </title>
[...]
  </description>
```

```
<manifestation>
[...]
  <item>
    <location>
      <uri>http://www.aspect-project.org/1</uri>
    </location>
  </item>
</manifestation>
<manifestation>
[...]
  <item>
    <location>
      <uri>http://www.aspect-project.org/?url=/file.php/downloads/1_ims_cc.zip</uri>
    </location>
  </item>
</manifestation>
[...]
```

Listing 1: An example ILOX description

The ILOX approach is implemented in the ASPECT Application Profile (Massart, Shulman & Van Assche 2010). IEEE LOM is still used to describe relevant attributes like title, author, etc. but ILOX is used as a wrapper container on top of this LOM to capture the different versions and formats of the same learning object. Listing 1 shows an example ILOX description of the LO about Pieter Bruegel the Elder. This LO has 2 different manifestations: one in web-based format and another one in Common Cartridge (CC).

Qualify the LOM location

The second possibility to point to the right version and format is to qualify the location of a learning object by profiling the LOM metadata element technical.location (4.3). These qualifications can be part of a normal LOM. For example the English language version and the IMS-CC format could be associated with a location URL such as http://www.ariadne-eu.org/LO987654/en/imscc.zip and the Dutch SCORM one would be http://www.ariadne-eu.org/LO192837.zip.

While one could argue that for e.g. language is already specified in section 1.3 of the LOM, a version of the same work might use a combination of facets. For example, there might be a Dutch SCORM version and an English IMS CC version, but not a Dutch IMS CC version. An example is depicted in Fig. 3. It is hence important to be able to distinguish specific combinations of different facets as opposed to allowing the full Cartesian product of different facets.

Following this approach, a profile of LOM section 4.3 (technical.location) is given in table 1. In this profile, a qualification is given by a tuple <facet, value>. For a location, multiple facets can be used.

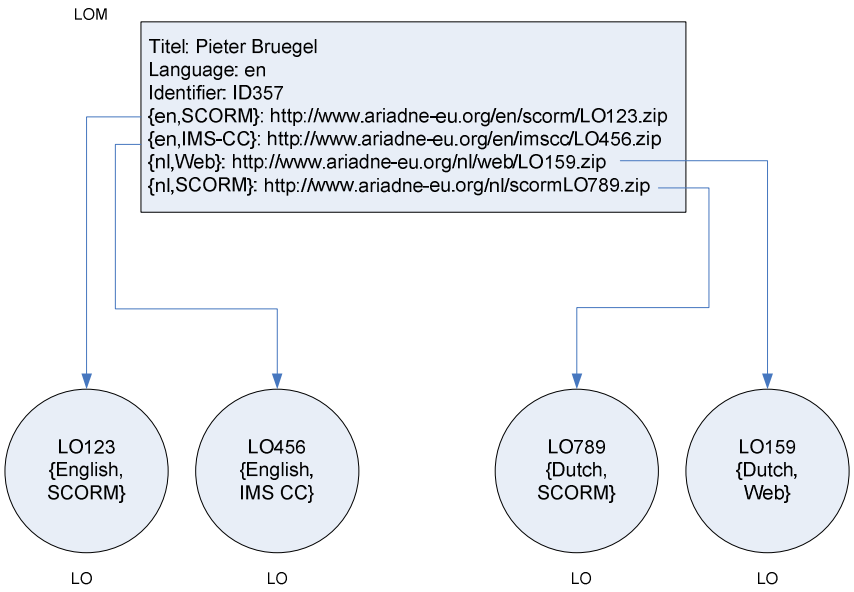

Fig. 3: Qualifying the LOM location.

Nr	Name	Description	Multiplicity	Order	Value space	Data type	Note	Example
4.3	Location	A string that is used to access this learning object	0..* (10)	Ordered	Repertoire of ISO/IEC 10646-1:2000	CharacterString (smallest permitted maximum: 1000 char)	Recommended data element. This is where the learning object described by this metadata instance is physically located.	http://www.ariadne-eu.org/LO987654/en/imscc.zip
4.3.1	Qualifier	This metadata element qualifies the location identifier such as provided with the handle system	0..* (10)	Unordered		This is a container element	This is a container	<”format”,” imsccv1.0”> <”accessibility”,”no red”>
4.3.1.1	Type	The facets taken into account for distinguishing different versions of the same LO (i.e. in FRBR terminology: the same work)	1	Unspecified	language format accessibility	Vocabulary term		“format”
4.3.1.2	Value	Contains a token for a facet of the technical location	1	Unspecified		VocabularyTerm taken from a vocabulary that corresponds to the qualifier type		imsccv1.0

Table 1: Qualifying technical location

Qualify the LOM location with an identifier service

An identifier service is usually only used for resolving to a single handle. However, the Handle System identifier service (Handle, 2009) has possibilities to give separate handles according to qualifiers. This solution is depicted in Fig. 4. The RFC 3650 Handle System Overview reads:

> *"Multiple Attributes: A single handle can refer to multiple attributes of a resource, including associated services, available through any method at different and possibly changing network locations. Handles can thus be used as persistent entry points into an evolving world of services associated with identified resources"*

Given this possibility, one could qualify the LO identifier in the LOM such that it resolves to the right version and format. Therefore, one has a single identifier with different resolutions according to certain qualifications. The same application profile as in table 1 could be used. This solution is similar to the "content negotiation" –mechanism. This mechanism in the HTTP specification makes it possible to serve different versions of a document (or more generally, a resource) at the same URI, so that user agents can specify which version fit their capabilities the best. For instance, to request a version in French, a browser would send the following header: "Accept-Language: fr"

As such the identity service would be able to address at least the problem that there are different LOs, corresponding with different facets. However, it cannot solve the problem that certain versions have some different metadata such as intended audience or rights.

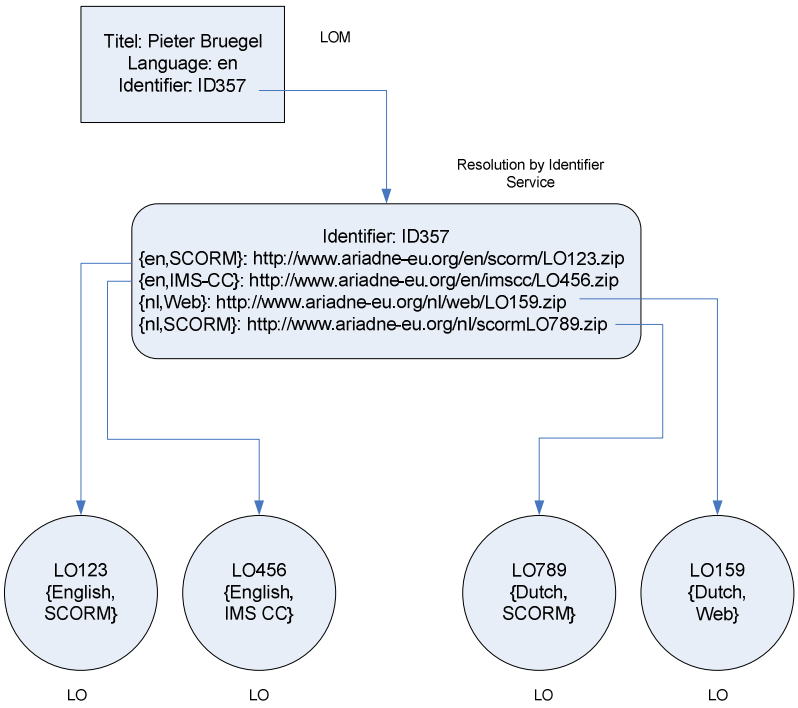

Fig. 4: Using attributes in the identifier service

Create recursive LOM instances

In some cases qualifying the location might not be enough. For example, it might be the case that the web-based format is a simpler version and therefore, other rights could be attached. A version for the colour blind might have a different intended target audience. In such cases, it is not only a matter of just qualifying the location, but several parts of the LOM are different for different cases. For such a situation, a recursive LOM can be used.

A first solution how to achieve this, is to extend the vocabulary of LOM section 7 (relation) as depicted in Fig. 5. In this solution, the LOM recurs using a new 'hasmetadatapart' relation that we declare in section 7 (relation) of the LOM standard. This solution of having a recursive LOM can be summarised as follows:

1. Each level takes a subset of the LOM.
2. Levels are related to each other with a new relation in section 7 of the LOM. The metadata item 7.1 gets an additional value 'hasmetadatapart' and possibly the inverse relationship 'ispartofmetadata'. In 7.2 the metadata identifier would be given instead of the LO identifier when the 7.1 is one of ('hasmetadatapart', 'ispartofmetadata').
3. Technical.Location is given in the leaf nodes

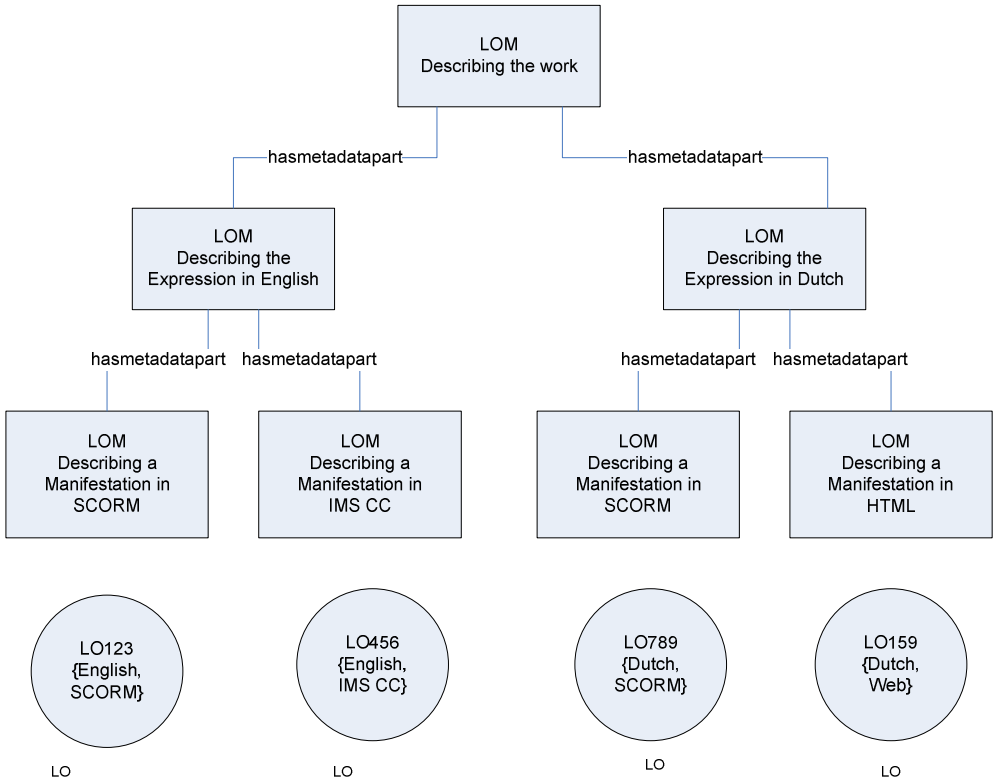

Fig. 5: A recursive LOM over a partative relationship using the value hasmetadatapart for metadata element 7.1 (kind) of the LOM.

A second solution for implementing a recursive LOM is to add a metadata element called 'relation' as part of section 3 (meta-metadata) instead of using a relation in section 7. This new metadata element (3.5) is a container element with 3.5.4 holding another LOM part, creating a nested structure. The corresponding metadata structure is presented in Table 2.

The advantage of making a separate section is that it is clear it concerns metadata (i.e. parts of the LOM) and that one can also specify the propagation rules (see element 3.5.3 in table 2). An application profile could discard this element by defining that in case a metadata element appears both in a parent and a child node, the metadata element in the child node always overrides the metadata element in the parent or the application profile could assume an overload strategy. The technical location is again given in the leaf nodes.

Another variant may be that instead of having another sub-LOM instance in 3.5.4, one would have a LOM metadata identifier pointing to another LOM instance. This new metadata element (3.5) is a container element with 3.5.4 holding another LOM part, creating a nested structured as depicted in Fig.6.

While this inclusion by reference does allow the use of the same parts in different wholes, it is not sure that it has an advantage. It would for example also mean that the parts would exist on their own. This could also make the implementation more complex. For instance, a simple algorithm would be needed to merge all recursive LOM first to be able to search on top of all information.

Nr	Name	Description	Multiplicity	Order	Value space	Data type	Note	Example
3.5	Metadata relationship	This metadata element holds another LOM instance in a recursive way	0..* (10)	Ordered	Repertoire of ISO/IEC 10646-1:2000	CharacterString (smallest permitted maximum: 1000 char)	A container metadata element. The order may give an indication of the preference. For example for 'format' this might be the preferred format. When using recursion one should be careful not to violate constraints, especially in the case of overload inheritance	
3.5.1	Relationship type	This metadata element qualifies the recursive LOM	0..1	Unspecified	language format accessibility	Vocabulary term	In an application profile this can be extended	"format"
3.5.2	Description	This metadata element gives more explanation about the nature of the relationship to the LOM instance in 10.4	0..1	Unspecified				
3.5.3	Inheritance	This metadata element describes whether the metadata elements specified in the LOM instance of 10.4 replace (override) the metadata elements of the LOM of which it is part or whether they should be taken in addition.	0..1	Unspecified	overload override	Vocabulary term		overload
3.5.4	Lom	This data element holds a LOM instance that is	1	Unspecified		A LOM instance		

Table 2: Recursive metadata as metadata relationship

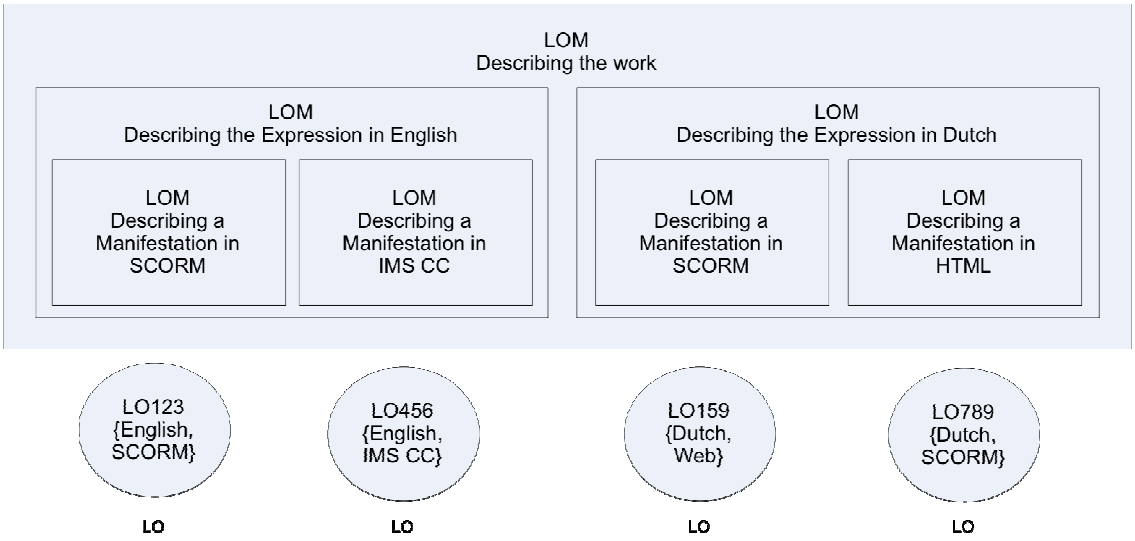

Figure 6: A nested LOM recurring over a partative relation in the metametadata section of the LOM

Discussion of the different possibilities

Each of the possibilities sketched above has both advantages and disadvantages. We discuss the different possibilities taking into account the following criteria: (a) expressive power, (b) fitting with current LOM practice, and (c) conceptual 'cleanness'. The following table summarizes all advantages and disadvantages. The different solutions may be more or less suited for one or more situations.

	expressive power	**fitting with current LOM practice**	**Conceptual 'cleanness'**
Create a wrapper container around LOM: ILOX	very good	limited	Excellent
Qualify LOM location (with identifier service)	limited	excellent	very good to excellent
Recursive LOM: extending LOM section 7: relation	very good	excellent	Good
Recursive LOM: extending LOM section 3: meta-metadata	very good	excellent	excellent

Table 3: Comparative evaluation of different approaches to expressions and formats

- *Creating a wrapper container (ILOX)* is a clean conceptual solution to our problem. However, as it is a wrapper on top of – *in the case of ASPECT* – LOM, it means that when content providers use the ILOX binding, they are not backwards compatible with all tools such as LMSs that support standard LOM. Those tools should either adapt to ILOX, or they should make use of a service for transforming ILOX back into LOM. This is quite a disadvantage as it breaks current interoperability between systems and tools.
- On the other hand, *qualifying the LOM location,* only adds an extra container element 4.3.1 (see table 1) to the LOM specification. This fits perfectly with current LOM practices because the addition of an extra field in the LOM does not break semantics. However, the expressive power of this solution is limited as it is difficult to e.g. have different rights for different versions of the same object. Relying on an identifier service would mean that all tools and systems should implement such service before they could allow different versions of the same learning objects. This is another level of implementation and is therefore not the most elegant solution. Although, if a content provider already has such service in place, it would not be difficult to use this solution.
- Extending either the *relation* or the *meta-metadata* sections of LOM are both very expressive solutions because the recursive LOM approach makes it able to capture different metadata for different versions of LOs in the different levels of the recursive structure. Besides that, these solutions are perfectly backwards compatible with current LOM practice. There is a small difference in the conceptual

cleanness of these approaches. We consider the meta-metadata approach excellent as it makes it very clear that this element relates to metadata. In this approach, a LOM instance can be an aggregate of multiple LOM instances.

Conclusions

This paper proposes and discusses three solutions for describing different versions of the same learning object. Such versions could be resources in different formats, languages, accessibility, etc. Currently, there is no best practice in current standards like LOM, DC, etc. how to capture this information. We propose and describe a recursive LOM approach where a LOM instance can be an aggregate of multiple LOM instances. This approach is very expressive and fits with current LOM practice. An initial validation with experts revealed that the latter approach has preference because of this expressive power but even more because of the fact that application profiles can be built that allow for backward compatibility with current LOM practice.

To empirically evaluate the benefits of this approach, we will introduce these solutions to both the content providers of the ASPECT and ICOPER eContent*Plus* projects and to the IMS LODE working group. We are currently working on a transform script for transforming all learning objects with multiple formats to the recursive LOM approach. This way, we will be able to have a strong idea on the usefulness, the clarity, and other possible advantages or disadvantages of our solution such as the impact on implementation issues. In the end, our goal is to create best practice in describing multiple versions of the same resources.

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